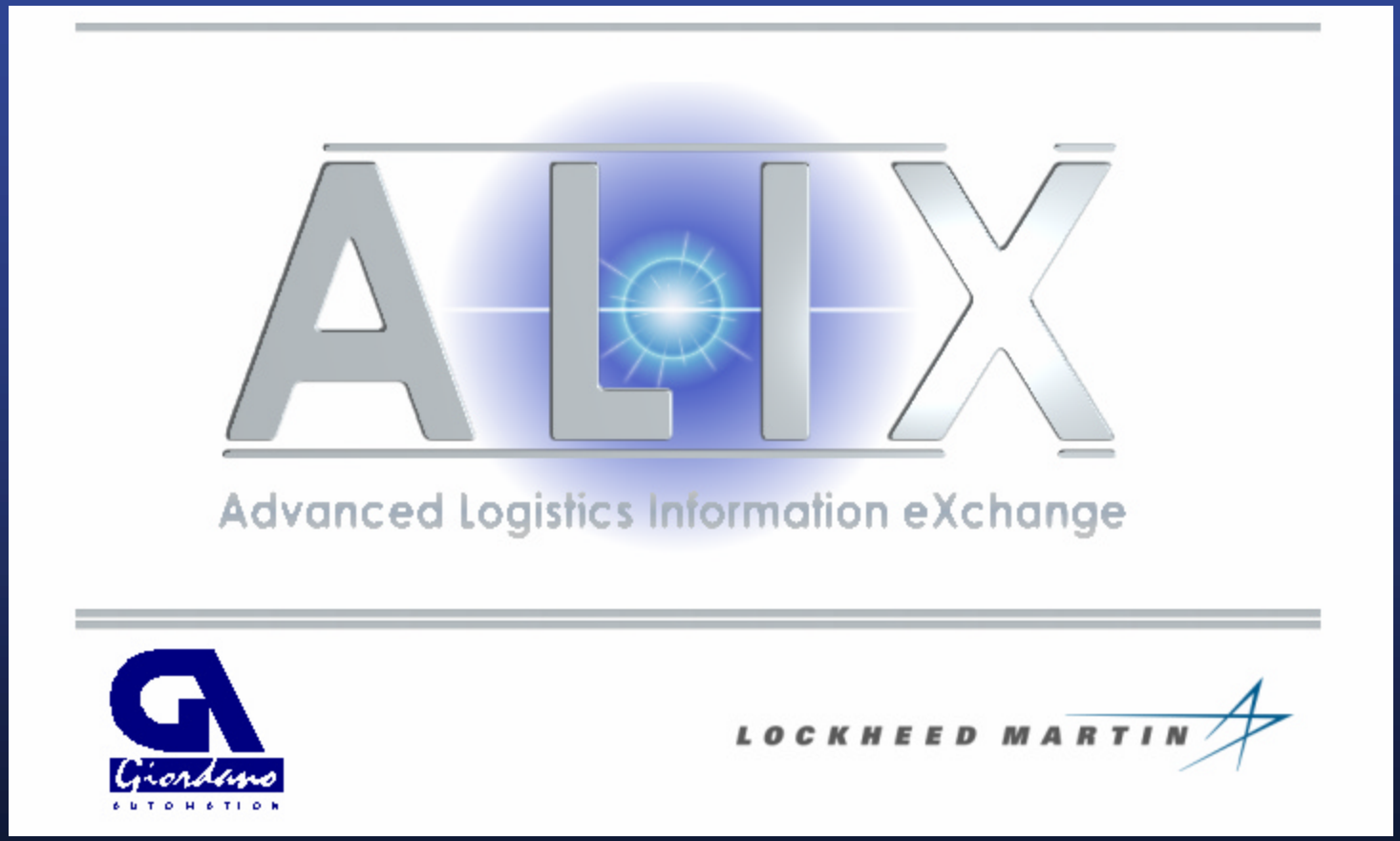
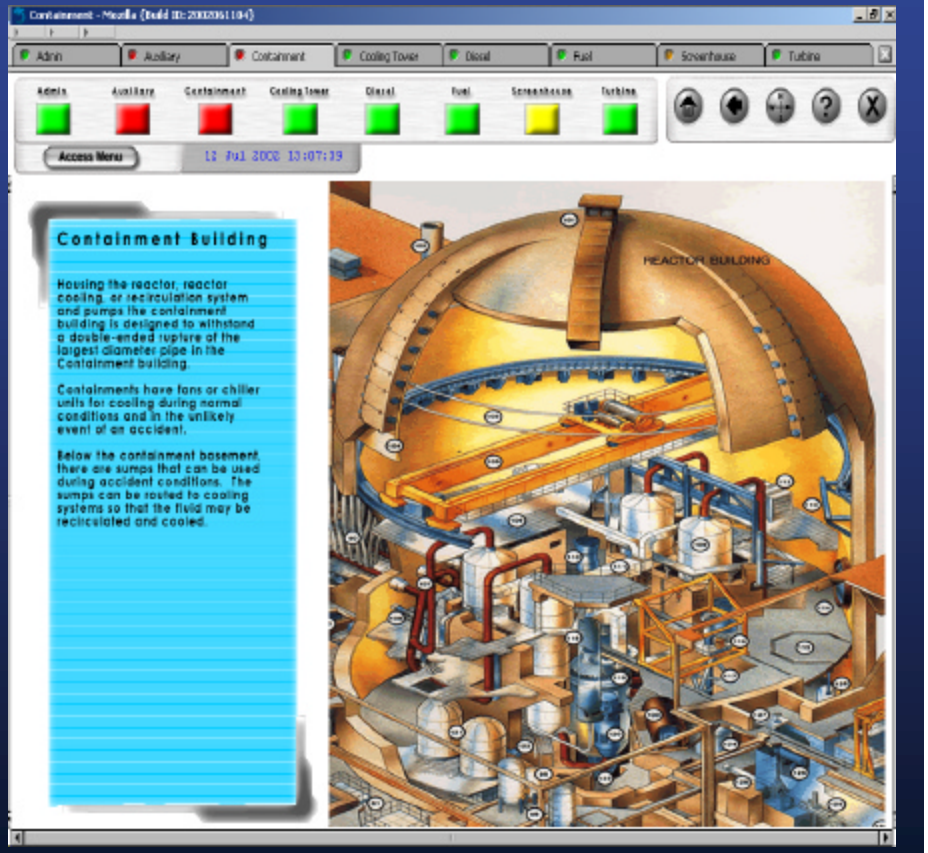


ALIX Employs Powerful Reasoning Technology* and Correlates Status and Predicted Status to System Availability

- **Advanced Logistic Information eXchange (ALIX) is a web-based integrated information system that will compliment existing systems to provide a prognosticating readiness environment allowing and aiding for proactive management of monitored systems. By integrating the various existing maintenance and readiness interfaces into a seamless package, ALIX will be able to effectively ensure systems are ready to fulfill mission critical objectives.**
- **ALIX provides a predictive element that will, by collecting existing electronic data and applying algorithms to that data, provide forecasts of systems degradation and / or failures before they actually fail.**
- **ALIX fully supports interfaces to legacy systems. Complimenting existing computer systems and making the collected data available to maintenance technicians, logistics coordinators, and management.**

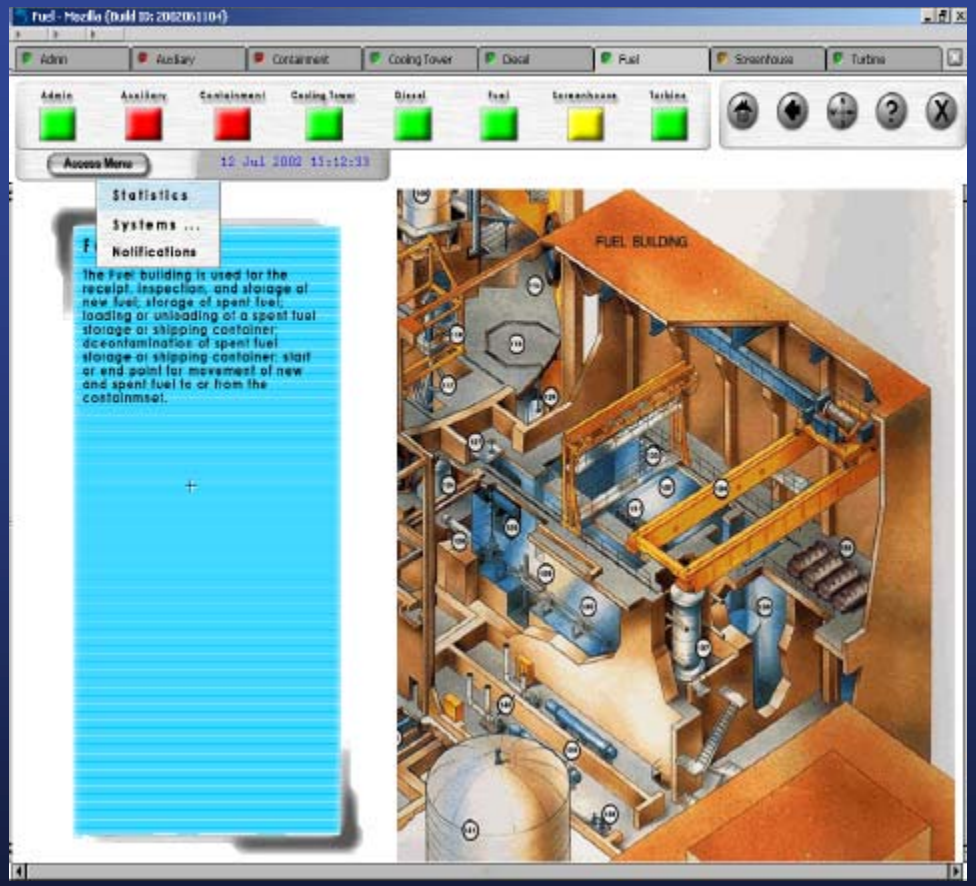


*Prognostics Framework Reasoning Technology provided by Giordano Automation

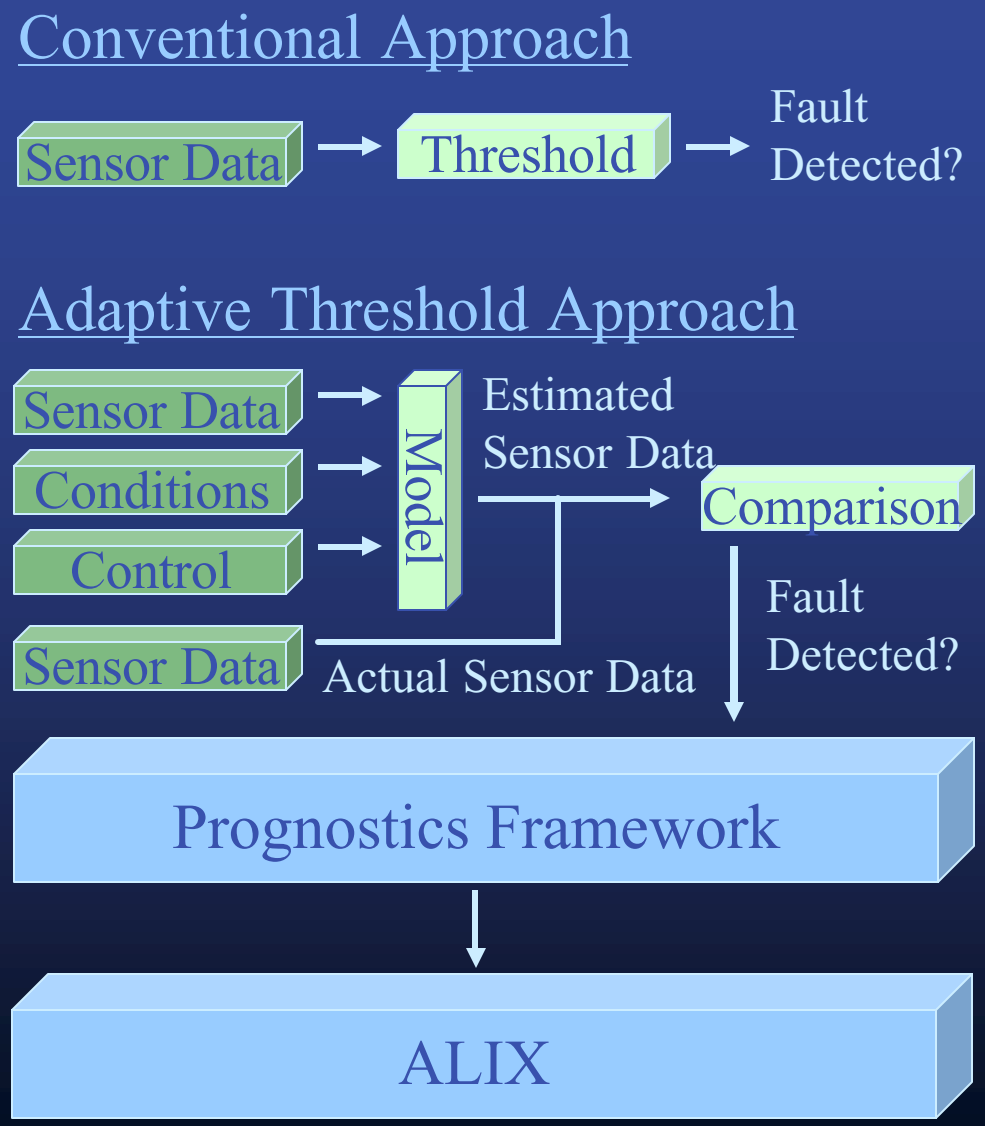
The Time for Change is NOW!!

- Breakthrough technology in *Model-Based Diagnostic Reasoning*
  - uses design-based model for diagnostics
  - eliminates diagnostic flow charts
- *Dynamic* Diagnostic capability
- Reads sensor data, built-in test and/or logged operational data; resolves BIT alarms & anomalies, applies filtering logic, performs fault isolation.
- Results in dramatic improvements in diagnostic accuracy; reductions in troubleshooting time

- A web based, structured information architecture to implement a health management capability
- Supporting systematic development and integration of diagnostics / prognostics
- Enables PMs to Converge on Prognostics as technology evolves
- Complement and Enhance Existing and Future Prognostics Mechanisms
- Open Architecture Tools, Object-Oriented Data

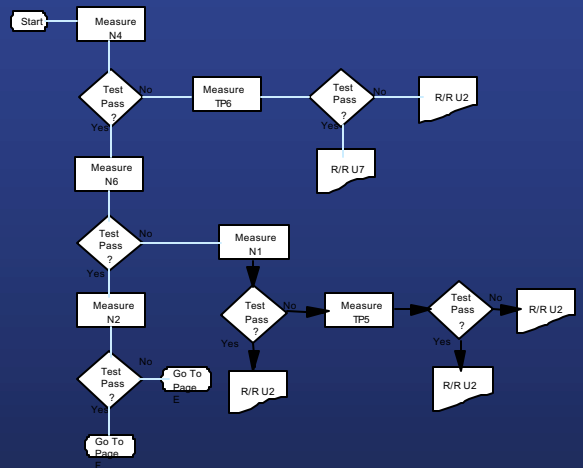


- Tighter threshold based on estimated sensor reading for specific operating conditions and control commands
- Increased fault detection
- Reduces false alarms and false dismissals
- Enables sensor validation based on inherently redundant sensor info



“Smart” Diagnostics

Troubleshooting Logic Tree (BIT, IETM, TPS)



Logic trees are an expert’s interpretation of how to best troubleshoot a piece of equipment:

* Static, Pre-Set Sequence
* Single fault assumption
* Labor intensive development
* Difficult to maintain

DIAGNOSTICIAN

(BIT, IETM, TPS)

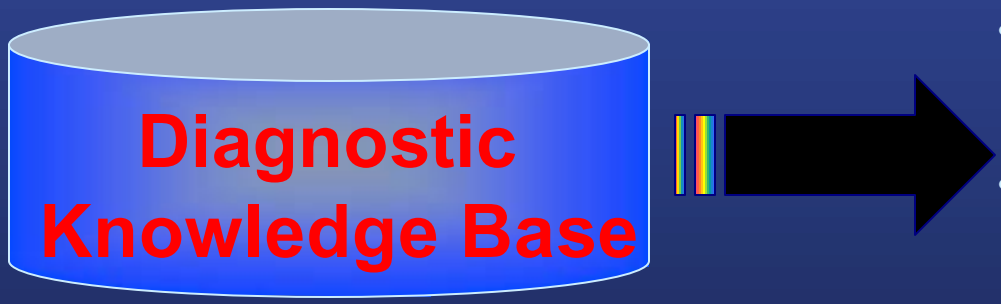
Derived from the design of the system!

Diagnostician is a set of “reasoning” algorithms that correlate all possible faults to all possible symptoms, or test results to provide fast, effective fault isolation.

* *Dynamically* bases its determinations based on a snapshot of current fault possibilities.
* Automated development and maintenance process.

"Smart" Diagnostics

DIAGNOSTICIAN (BIT, IETM, TPS)



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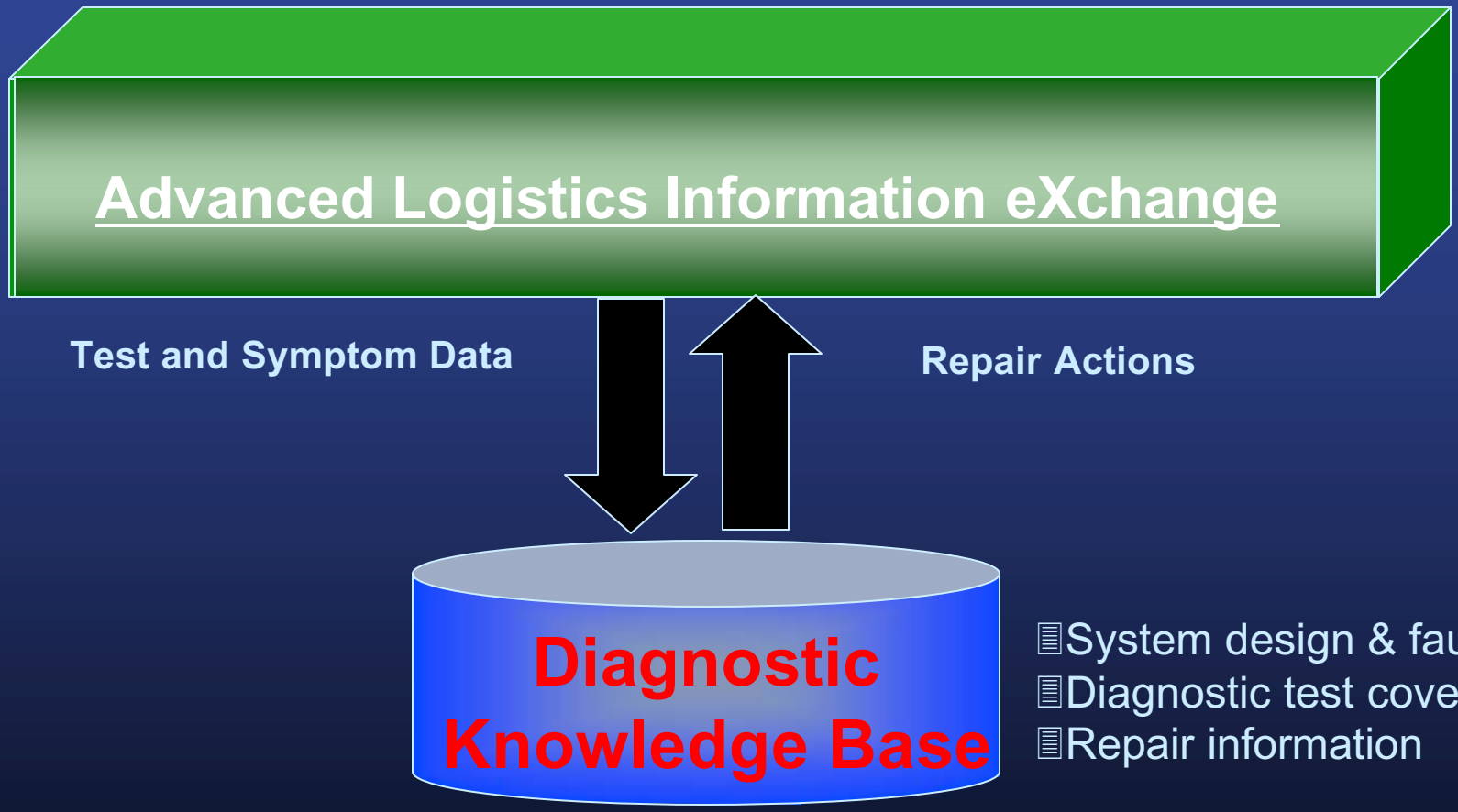
Knowledge Base Replaces Fault Trees

- Knowledge Base with Inference Engine Reads Event/BIT Data and identifies fault.
- Object Oriented enables Client-Server Integration
  * Integrated Diagnostics
  * Integrated Training
  * Integrated Maintenance
  * Integrated Data Collection

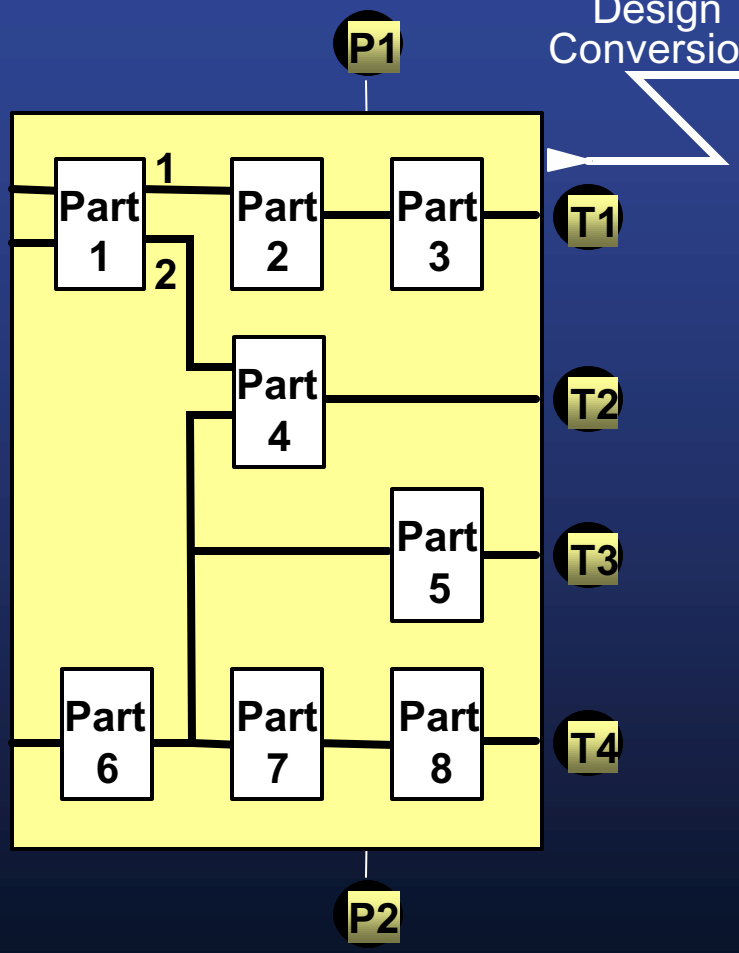
Diagnostician Fault Isolation



- System design & faults
- Diagnostic test coverage
- Repair information

Diagnostician is a set of reasoning algorithms which operate with a system's design information to provide *"Automated Diagnostics"* to an efficiently repairable level.

System Design → Fault/Symptom Matrix



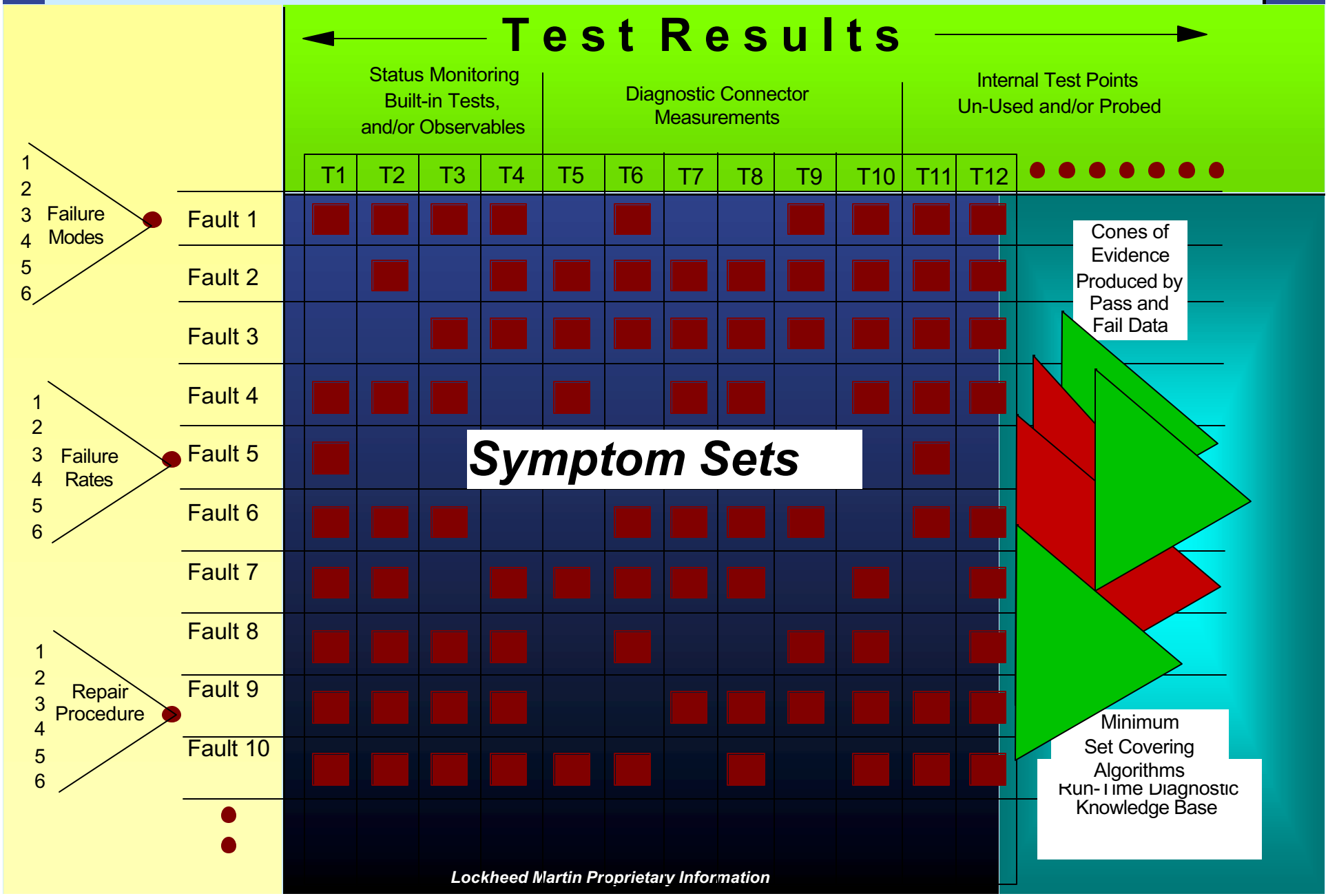
Automatic Design Conversion

FAULTS \ TESTS		T1	T2	T3	T4	P1	P2
Part 1	Output 1	X				X	
	Output 2		X				
Part 2	Output 1	X				X	
Part 3	Output 1	X					
Part 4	Output 1		X				
Part 5	Output 1			X			
Part 6	Output 1		X	X	X		X
Part 7	Output 1				X		X
Part 8	Output 1				X		

Fault Propagation →

Test Coverage ↓

Fault/Symptom Matrix



"Dynamic" Diagnostic Capability

Test Results can be input to the Diagnostician

in any order

no pre-set sequence

from any source individually or in sequence

operator observations, test instruments, data bus, data file, built-in test, automatic test equipment, system panels & displays, etc.

as many or as few at a time as the test source(s) can provide

not restricted to one-at-a-time to follow a diagnostic tree

zeroes-in on cause of fault(s)

Identify multiple faults

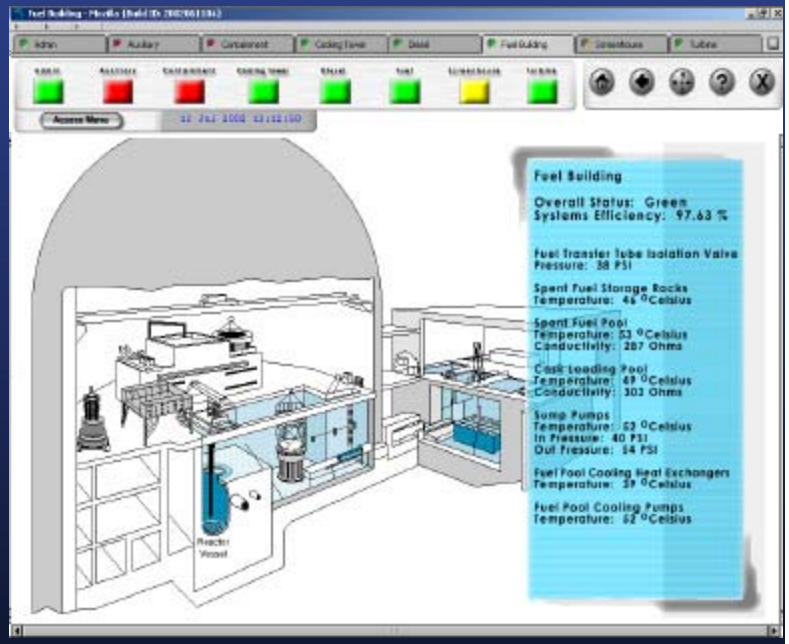
Diagnostic trees follow single-fault assumption

Will always zero in on cause of fault

never leaves the technician hanging

Only request tests that have diagnostic significance

based upon snapshot of current fault possibilities



Embedded Diagnostics Deficiencies

Most Built-in Test (BIT) Designed to Support Operations, Not Maintenance

- Focus on Fault Detection at function level

BIT Under-Accessed / Under-Utilized in Field Maintenance

- Reporting to higher system levels involves dilution of content

Solution is Available TODAY!

ALIX is an excellent way to put BIT into the "Maintenance" Realm

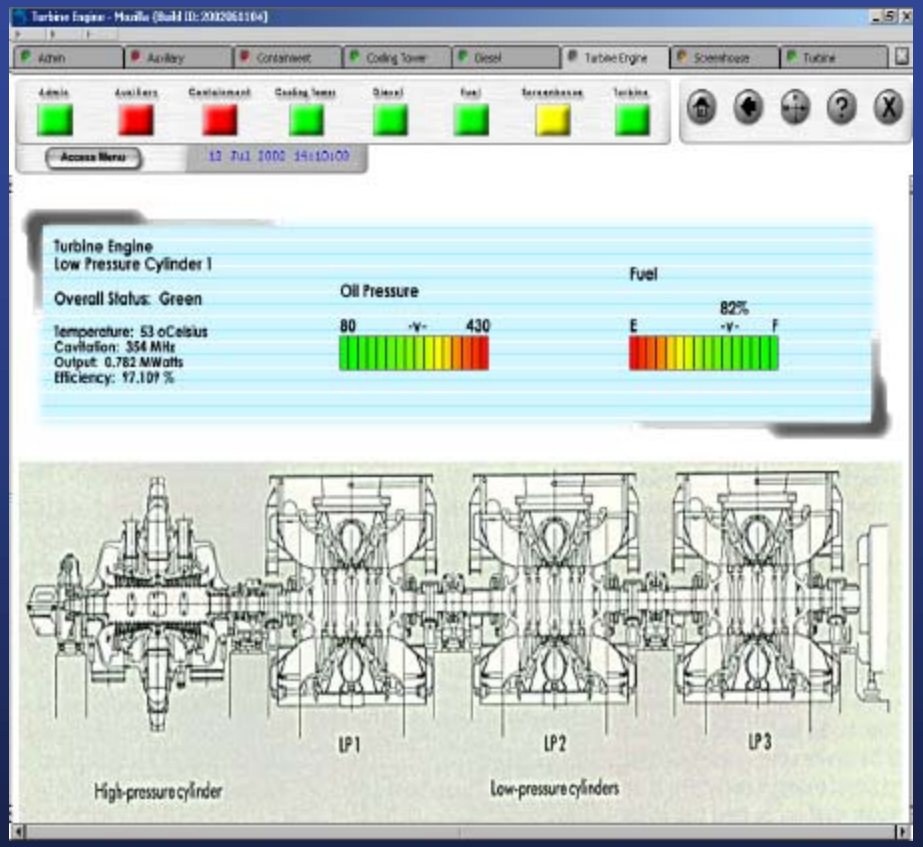
- Same BIT resources - coverage "mapped" across knowledge base
- Results in Fault Isolation!

Extends Built-in Test (BIT) to Built-in Diagnostics (BID)

Embedded Diagnostics Deficiencies

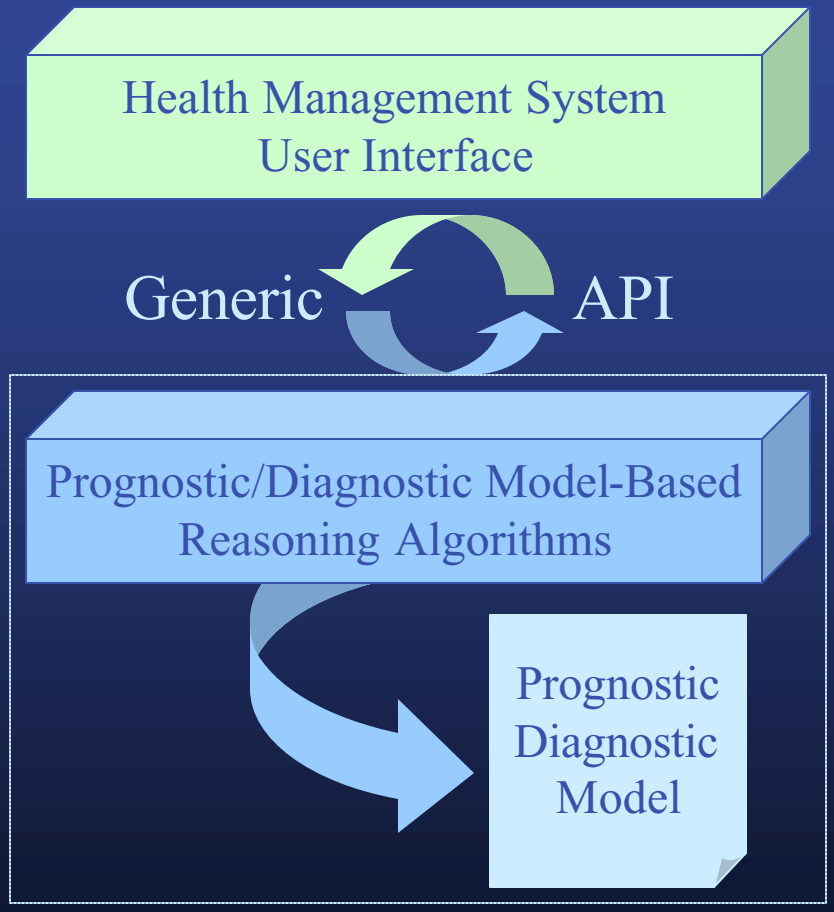
- Diagnostician Enables Interpretation of BIT at Component Level (much more granular)
- Transitions Functional Fault Detection to Component Level Fault Isolation
- Can be used in Centralized or Distributed Implementation Strategy
- Can be hosted on existing embedded processors
- On-line, real-time fault isolation
- Structured Functions for Data Logging and Run-Time "Smartening"
- Can Report Results to On-Line systems or Off-Line PMA to drive IETM

- This Turbine system, being specifically selected from the Access Menu provides a diagram of the Turbine system as well as detailed real-time data for the Turbine. By placing our mouse over the different areas of the Turbine we can see the present state of the Turbine's cylinders.



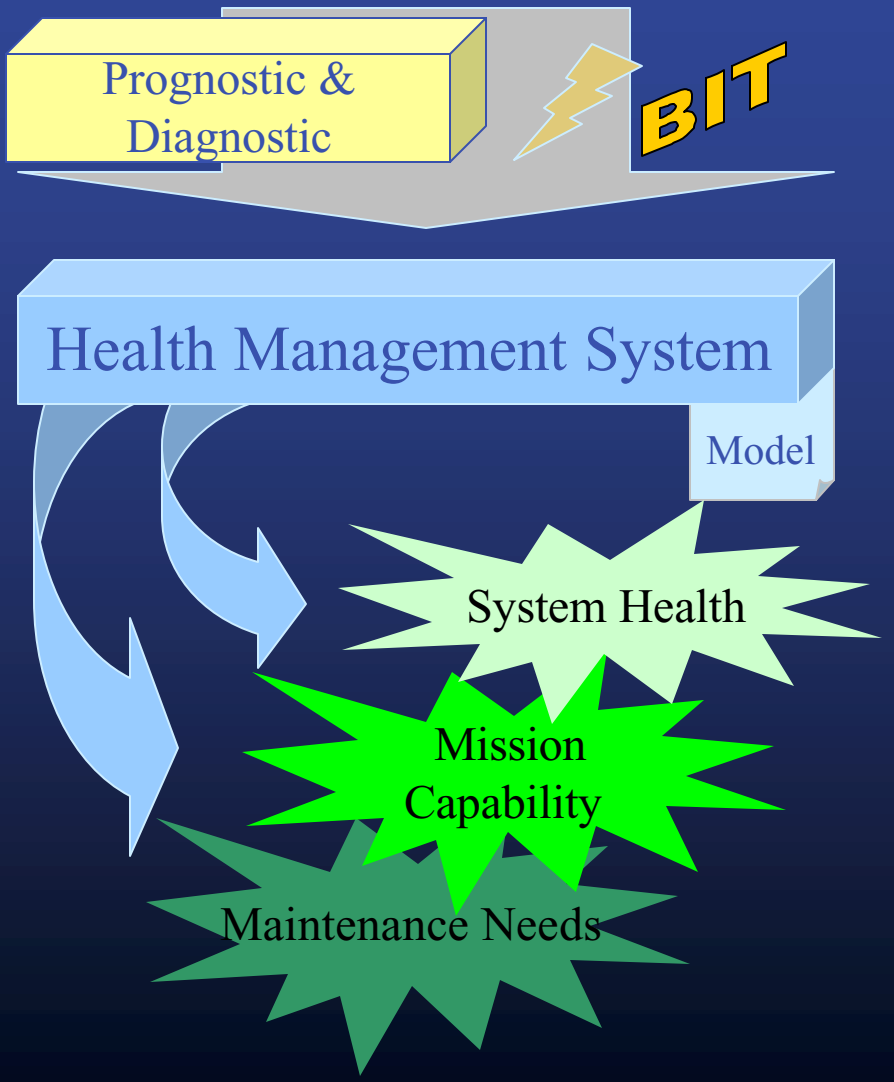
ON-BOARD HEALTH MANAGEMENT SYSTEM

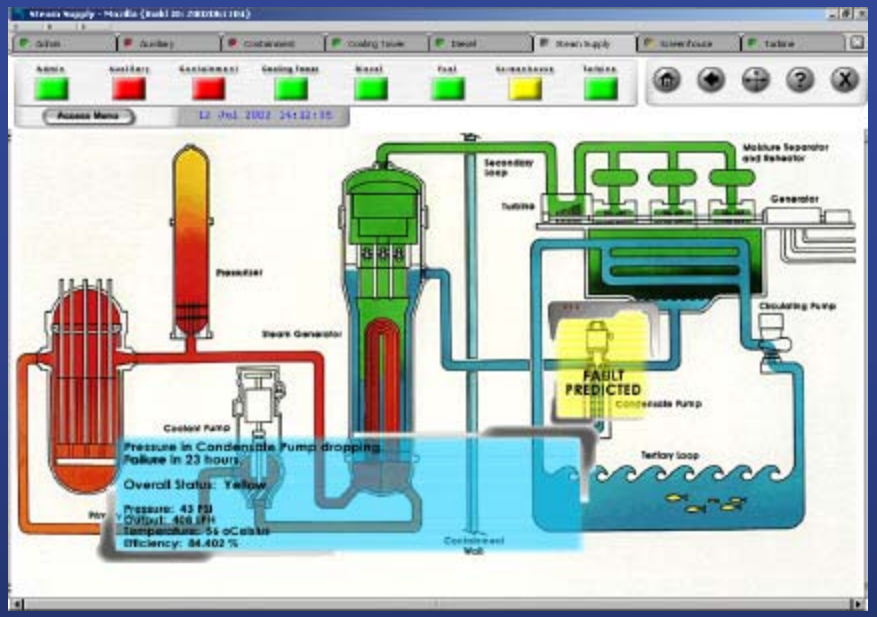
- Run-Time Software designed for embedded applications
- C Code that can be cross-compiled to any platform
- Implementation Strategy: Centralized, Distributed, Hierarchical
- Software functions serve as building blocks
  - Integrate building blocks to build desired functionality
  - Design User Interface as desired or use existing
  - Well-documented API

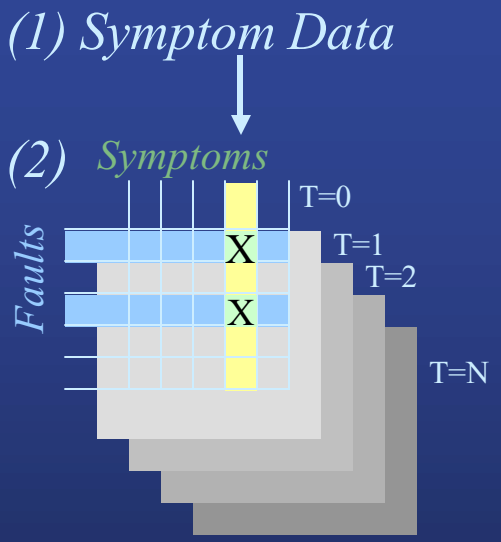


How does the Health Management System work?

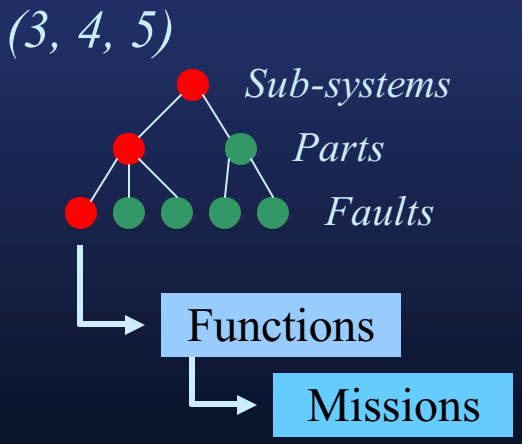
- **Embedded Environment**
  - **Monitors data inputs from sensors, BIT, and other prognostic/diagnostic mechanisms**
  - **Prognoses/Diagnoses failures in real time**
  - **Provides complete system monitoring**
- **Off-line Environment**
  - **Accepts all data available**
  - **Additional Prognosis/Diagnosis**
  - **Provides complete system health management**
  - **Anticipates maintenance needs**
  - **Integrates logistics software**







1. Accept prognostic/diagnostic software outputs, BIT and parametric data as *symptoms*
2. Apply model-based reasoning AI algorithms to prognose/diagnose the implication of out of tolerance *symptoms* on each future time point defined in the model
3. Identify the components and sub-systems affected by predicted failures - *sub-system health*
4. Identify the functions and missions affected by predicted failures - *mission readiness*
5. Identify the repair actions needed - *anticipatory maintenance*



Benefits

- Generically Applicable Diagnostic Capability
  - Advanced Logistics Information eXchange (ALIX) can be applied to any type of system … system application cost savings
- Multi-tier integrated diagnostics
  - Diagnostic information from previous levels of maintenance used to improve fault isolation
  - Diagnostic history captured to improve engineering analysis support
- Enhanced diagnostic capabilities
  - Dynamic diagnostics - improved troubleshooting process with more flexibility when troubleshooting equipment is unavailable
  - Simplified IETM structure for easier development & maintenance
  - Multiple fault isolation
- Customer Ownership and Control of Diagnostic Data

Additional Benefits of "Smart Diagnostics"

Enable a higher level of integration

- With system BIT, off-line testing, visual observations, etc.
- With maintenance training systems
- With Readiness Monitoring

Run-Time Smartening

- Log Session History Data
- Serial Number Tracking
- Create Maintenance History
- Trend Analysis
- Update Failure Rates

Improve diagnostic accuracy over time based upon field experience

- Reduce / Eliminate Retest OK Rates
- New/Unforeseen Failure modes
- Actual Failure Rate Data
- Automate Data Collection & Logging

Resulting Diagnostic Capability

- Will be better than traditional diagnostics
  - (Algorithms use pass & fail data, minimum set covering, etc., which gives better diagnostic resolution for test data)
- Will cost less to implement
  - No hard-coded diagnostic logic
- Will be easier to update & maintain
  - Design changes / Test changes easily introduced to Knowledge Base

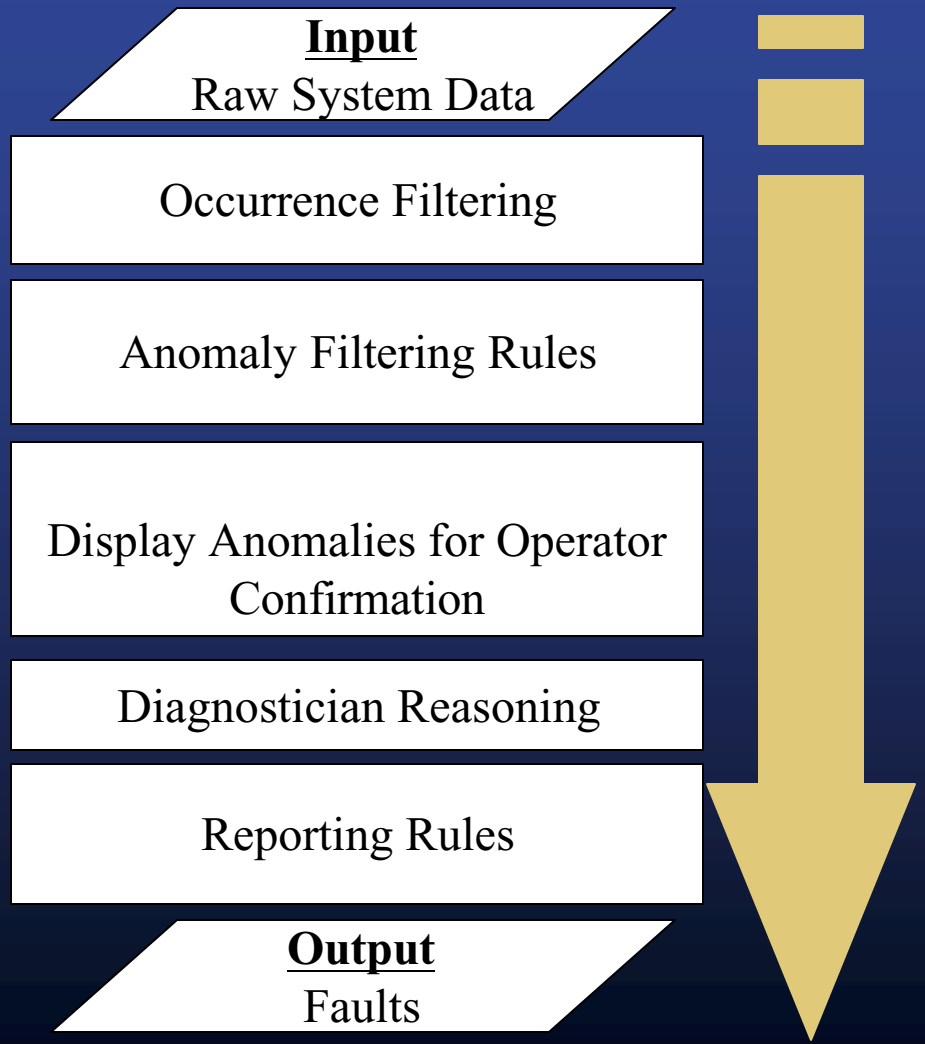
Input Alternatives

- Applicable Import Utilities
  - EDIF Netlist files
  - eXpress Outputs (leverage off investment made in testability modeling)
  - Tagged format (Fault Tree Import)
  - Functional Model Builder
  - FMECA Data Import
- Not Really Applicable:
  - Digital Fault Simulator Import

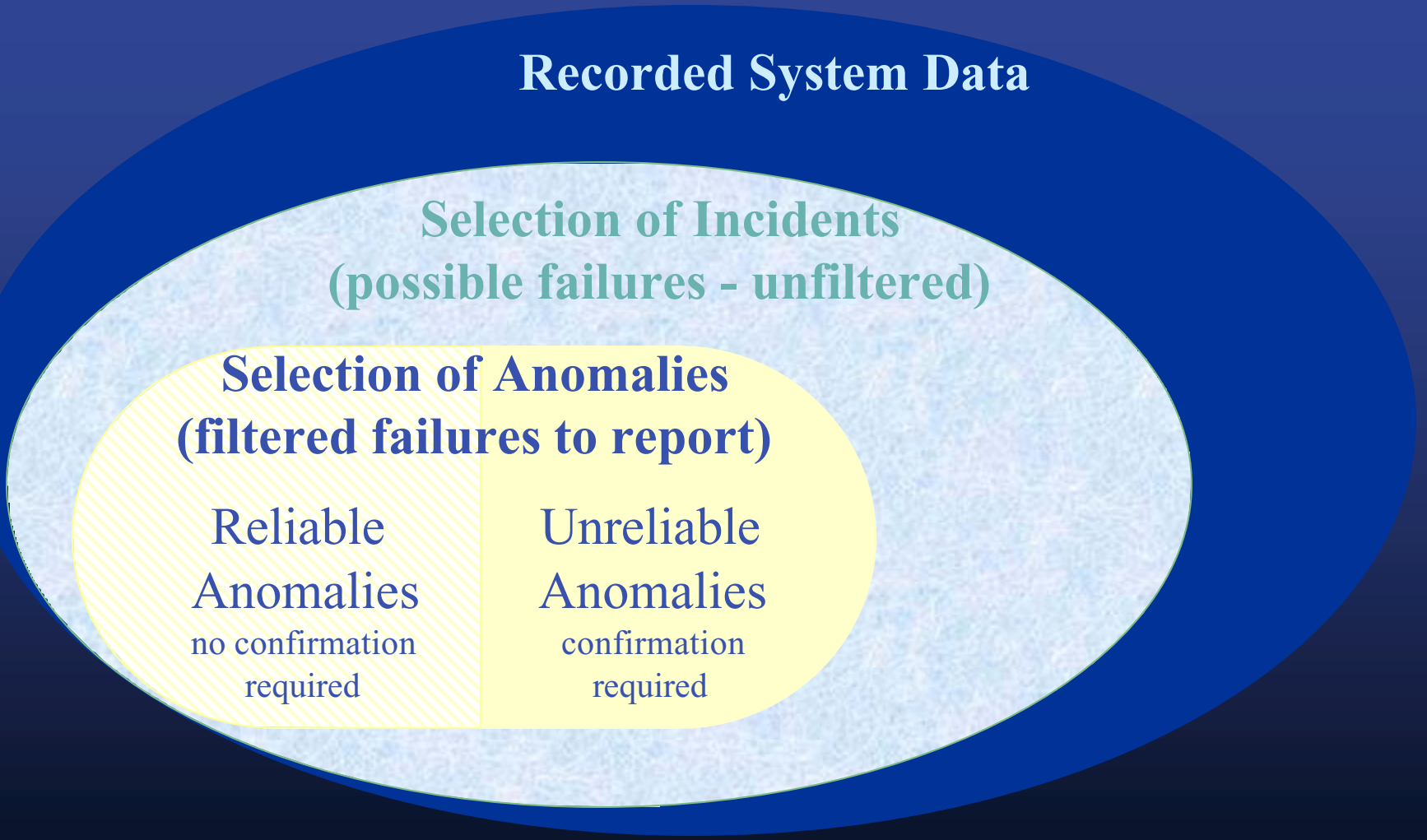
Applications Potential is Unlimited…

- Built-in diagnostics for systems / sub-systems
- Integrated health monitoring and fault management systems
- Fault Tolerant Systems (adaptive model for reconfigurable systems)
- SMART automatic test systems
- Field service testers with Inference Engine and Smart PCMCIA-based knowledge bases
- Intelligent technical manuals
- Interactive Adaptive training systems

Event Processing



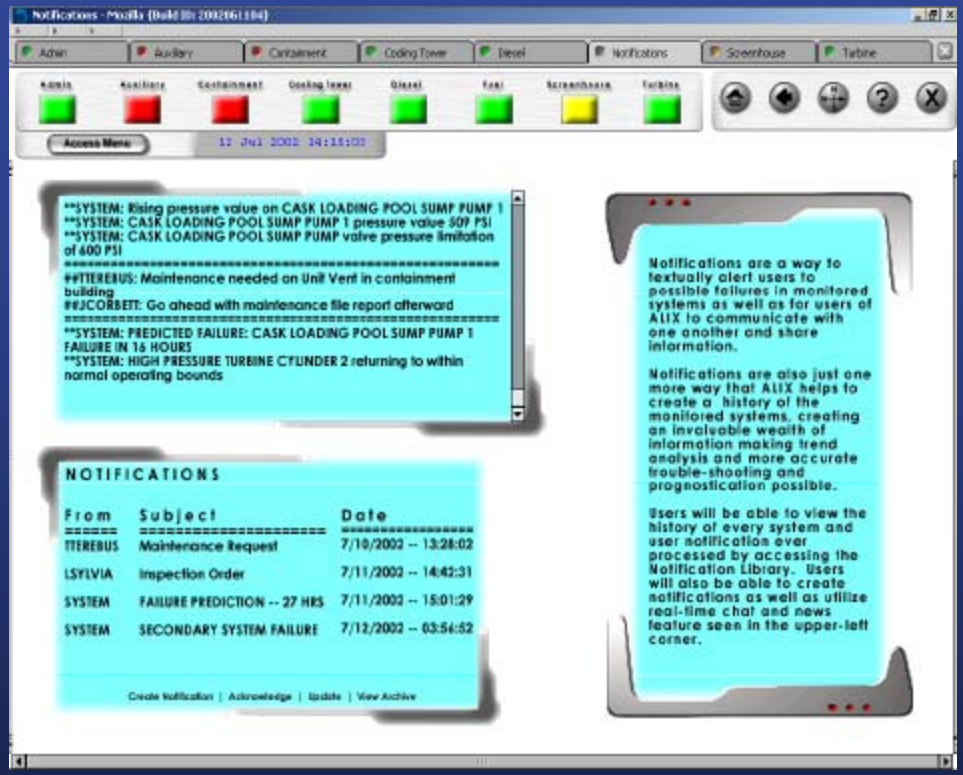
Data Concepts



Types of Rules

- **Multiple Occurrence Filtering**
  - Rules based on time frames and number of occurrences will be used to group multiple occurrences of fault codes into failure incidents
- **Anomaly Filtering**
  - Rules and Boolean expressions of incident occurrences and parametric data values are used to group, accept, reject incidents to form anomalies that will be reported by debrief as failures
    - filters false alarms
    - determines the reliability of fault codes
    - disregards fault codes as nuisance faults
    - determines whether pilot confirmation is needed
- **Reporting Rules**
  - Rules and Boolean expressions are used to determine if and how a fault code should be reported

- Notifications are a primary tool allowing communications to the user from ALIX as well as other users. The screen displayed here shows in the upper-left a real-time chat window providing messages posted by the users as well as by ALIX itself. Below that on the left is a display of all currently posted Notifications awaiting approval / acknowledgement by the user. In addition to on-screen notifications, fault predictions can also be sent to technicians via email and cellular pager..



The ALIX system is the next generation of remote administration / monitoring tools.; providing a customized interface, unlimited extensible functionality, and multiple roles for multiple users.

To Learn More Contact:

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